Proposing and Conducting Experiments at the FAST Linac and IOTA Ring

Giulio Stancari for the
IOTA/FAST Scientific Committee (ISC)

FAST/IOTA Collaboration Meeting
Fermilab, June 15-17, 2020

indico.fnal.gov/event/43231

Motivation

The facility is dedicated to **research** and **education** in beam physics and accelerator technology

The IOTA/FAST Scientific Committee works with the experimenters to achieve these goals:

- Encourage a **vibrant scientific program**
- Establish transparent resource and schedule **priorities**
- Ensure adequate **planning** of experiments
- **Document** research done at the facility
- **Keep the process simple**, to serve a flexible facility with frequent apparatus modifications and experiments running in parallel

Resources on the IOTA/FAST Scientific Committee Web Page

IOTA »

IOTA/FAST Scientific Committee (ISC)

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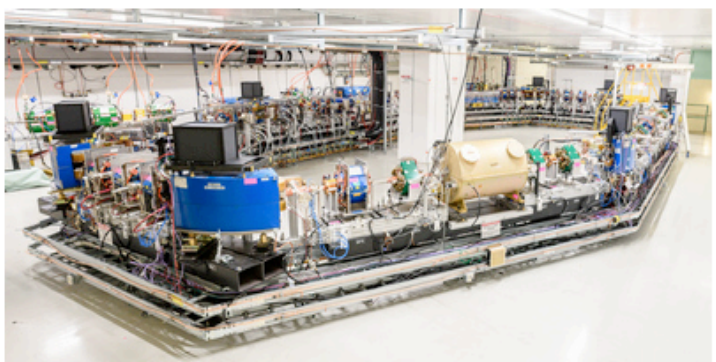
Proposing an experiment at IOTA/FAST

- Proposal submission guidelines: Beams-doc-7363
- Proposal template [PDF] [LaTeX]
- Presentation given at the FAST/IOTA Collaboration Meeting (June 2019)
- Note on data storage options for IOTA/FAST experiments: Beams-doc-8245



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cdcvs.fnal.gov/redmine/projects/ifsc/wiki/

Experiments in Run 2

Run 2 was divided into two periods. Run 2a mostly dedicated to commissioning.
7 experiments in IOTA and 2 in FAST Linac, carried out in Run 2b.

Run 2a (Nov 27, 2019 - Dec 20, 2019) and Run 2b (Feb 17, 2020 - Mar 21, 2020)

IOTA

ID	Acronym	Title	Spokesperson	LOI (optional)	Proposal	Presentation	Status
I-201	NL-OMC	Nonlinear Optics Measurements and Correction in the IOTA Ring	M. Hofer (CERN)	PDF	PDF	slides	approved
I-203	IBS_Study	Study of Intrabeam Scattering	V. Lebedev (FNAL)	no	PDF	slides	approved
I-204	NIO	Nonlinear Integrable Optics in Run 2	A. Valishev (FNAL)	no	PDF	slides	approved
I-205	AMPUR	Angular Measurement of Photons from Undulator Radiation in IOTA's Single Electron Mode	E. Angelico (UChicago)	no	PDF	slides	approved
I-206	URSSE	Measurement of Spontaneous Undulator Radiation Statistics Generated by a Single Electron	S. Nagaitsev (FNAL/UChicago)	no	PDF	slides	approved
I-208	SI	Quasi-integrable systems based on symplectic integrators	S. Baturin (NIU)	no	PDF	slides	rejected
I-209	FUR	Fluctuations in undulator radiation	I. Lobach (UChicago)	no	PDF	slides	approved
I-210	NIOLD	Instability thresholds and integrable optics	N. Eddy (FNAL)	PDF1 PDF2	PDF	slides	approved

FAST linac

ID	Acronym	Title	Spokesperson	LOI (optional)	Proposal	Presentation	Status
I-202	LRW/SRW	Investigations of Long-range and Short-range Wakefield Effects on Beam Dynamics in TESLA-type Superconducting Cavities	A. Lumpkin (FNAL)	yes	PDF	slides	approved
I-207	MagBeam	Generation, Transport and Diagnostics of High-charge Magnetized Beams	P. Piot (NIU/ANL)	yes	PDF	slides	approved

cdcvs.fnal.gov/redmine/projects/ifsc/wiki/

Background on Experiments and Proposals

Proposals can be submitted any time. The ISC meets regularly, with special meetings as needed (e.g., during a run, when new ideas may emerge)

An '**experiment**' is defined by the scope of the proposal and it is **completed within one experimental run**.

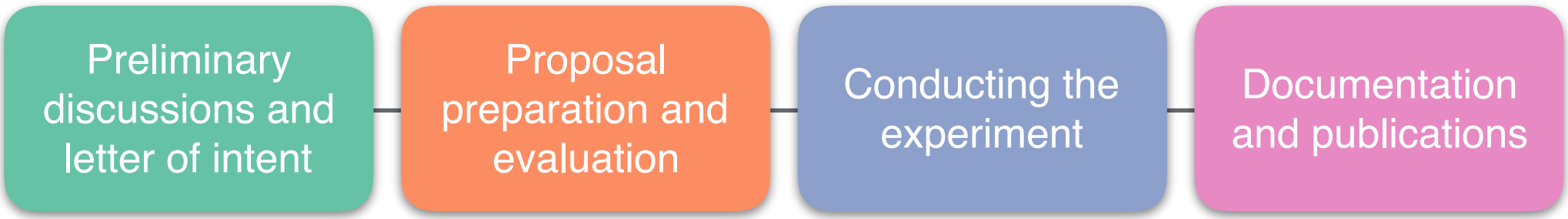
A '**research program**' can span **multiple runs** and include **more than one experiment or proposal** (e.g.: nonlinear integrable optics, optical stochastic cooling, undulator radiation from single electrons)

Experiments designate a **Spokesperson** or Principal Investigator (PI) and, optionally, a **Deputy Spokesperson**. If both are external, a **Fermilab Liaison** must be identified.

[Note: External collaborators register as Fermilab Users within the *FAST/IOTA Collaboration*, which acts as a general *umbrella organization for administrative purposes*]

Information and Comments on the Experiment Cycle

Main components of an experiment:



Preliminary Discussions and Letter of Intent

The project is discussed with interested parties and with Fermilab staff.

A **letter of intent** is sent by e-mail to one of the members of the ISC. The LOI is an **informal written document** (from a few paragraphs up to 4 pages).

The LOI helps define the scope of the experiment, makes the ISC aware of the request, and starts the proposal preparation process.

The LOI is optional, but recommended.

Proposal Preparation and Submission

The **formal proposal** is a **detailed written document** describing the scientific and technical aspects of the experiment.

The proposal includes:

- title
- personnel, with specific roles and responsibilities [e.g., see casrai.org/credit]
- purpose and methods
- required beam conditions
- apparatus and necessary infrastructure
- run plan and shift request
- internal and external resources
- supporting documents and other relevant information

A template with instructions is available on the ISC web site
cdcvs.fnal.gov/redmine/projects/ifsc/wiki

The **written proposal** is sent by e-mail to the ISC. An **oral presentation** is scheduled to discuss the proposal.

A well prepared and well written proposal is essential for the success of an experiment.

Scientific and Technical Reviews

The **scientific review** is carried out by the ISC. Evaluation is based upon scientific merit, as defined, for instance, by current literature, support of independent experts or relevance to the Fermilab program.

The **technical review** is coordinated by the Head of the FAST Facility Department. It includes safety, feasibility, resource availability, schedule and impact on other projects.

The **outcome** of the reviews may be

- ***rejection*** — with written motivation
- ***deferral*** — if more preparatory work is needed
- ***approval*** — the experiment is included in the experimental program and operations schedule

Scheduling and Data Taking

For approved experiments:

- The **schedule** is determined by the **Run Coordinator**
- The shift schedule takes into account **priorities** and **compatibility** with other studies
- The schedule incorporates **flexibility**
  - to allow external collaborators to participate
  - to mitigate the challenges of simultaneously setting up experiments, collecting data, and running preliminary analyses
- Experimenters are expected to give **brief periodic updates** during the run (e.g.: 10-minute status reports at the weekly Friday meetings)

Documentation and Publications

It is expected that approved experiments

- **Maintain a web site** with documents, pictures, data, computer code, internal notes, papers, etc. Infrastructure at Fermilab is available through Redmine, if experimenters choose this option. Dedicated data storage is also available.

We have made progress, but we need to do a better job. Documentation and reproducibility of research is essential. Moreover, tools developed for one experiment may be useful for other studies.

- **Publish results** as soon as possible (at least one report within 6 months of run). There are various publication **options**, depending on the nature of the results:
  - peer-reviewed **journals**: *Phys. Rev. Accel. Beams*, *Nucl. Instrum. Methods*, *J. Instrum.*, …
  - conference **proceedings**: IPAC, LINAC, …
  - Fermilab **reports**:
    - » physics notes (FERMILAB-FN)
    - » technical memos (FERMILAB-TM)
  - Accelerator Division **notes**:
    - » Beams-doc: (beamdocs.fnal.gov)

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Journal of Instrumentation

Accelerator Science and Technology Research at the Fermilab Integrable Optics Test Accelerator

Editors

Giulio Stancari and Alexander Valishev from Fermi National Accelerator Laboratory

The Integrable Optics Test Accelerator (IOTA) at Fermilab is a storage ring dedicated to beam physics research. Its purpose is threefold: to address the challenges posed by future high-intensity machines, such as instabilities and losses; to carry out basic research in beam physics; and to provide education and training for scientists and engineers.

IOTA is unique in its research mission, as well as in its flexibility and accuracy. It has a circumference of 40 m and a relatively large aperture (50 mm). It is easily reconfigurable to accommodate the installation of different experiments. Because of the quality of the instrumentation, the magnetic lattice can be precisely controlled. In addition, the lattice was designed to have significant flexibility to enable a wide variety of studies. IOTA can store electrons up to 150 MeV or protons at 2.5 MeV.

Because of synchrotron-radiation damping, electrons are suited to the study of linear and nonlinear single-particle effects. Proton dynamics, on the other hand, is dominated by space charge. Electrons were circulated for the first time in August 2018. Proton beams will become available in 2021 and will open up research on high-intensity beams.

The IOTA research program includes the experimental study of nonlinear integrable focusing systems based on special magnets or on electron lenses. Because of their nonlinearity, these systems generate a betatron tune spread that protects the beam from instabilities through Landau damping. Integrability ensures that the nonlinear system does not reduce the dynamic aperture of the machine, therefore preserving beam lifetime and emittance. Several other topics will be studied in IOTA, such as the experimental demonstration of optical stochastic cooling and the compensation of space-charge effects. In addition, IOTA has the capability of storing single electrons. Experiments on the spatial and temporal distribution of undulator radiation from single electrons are under way.

This Special Issue of the Journal of Instrumentation includes articles on the research conducted at IOTA, technical reports on the facility, descriptions of the instrumentation used for beam diagnostics, and discussions of the experimental results.

Giulio Stancari and Alexander Valishev
Fermi National Accelerator Laboratory

Papers

Single-particle dynamics in a nonlinear accelerator lattice: attaining a large tune spread with octupoles in IOTA
S.A. Antipov *et al* 2017 *JINST* **12** P04008
+ View abstract View article PDF

OPEN ACCESS
IOTA (Integrable Optics Test Accelerator): facility and experimental beam physics program
S. Antipov *et al* 2017 *JINST* **12** T03002
+ View abstract View article PDF

Special Issue of JINST dedicated to IOTA, thanks to Vladimir Shiltsev as member of the Editorial Board for the initiative

Wide scope: theory and modeling; experimental results; technical reports; instrumentation

Two articles already included: (1) general facility and program; (2) nonlinear integrable optics with octupoles

Examples of candidate contributions:

- optical stochastic cooling design report
- lifetime model and measurements
- beam-position monitoring
- synchrotron-light diagnostic system
- nonlinear integrable optics models and simulations

Alexander Valishev and I will serve as **Editors**

https://iopscience.iop.org/journal/1748-0221/page/extraproc90

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Outlook: Run 3 and Beyond

Proposals and **new concepts** will be presented during experiment reports and during Wednesday sessions. Looking forward to stimulating discussions.

Feasible in **Run 3** (~ Sep-Dec 2020), expecting proposals:

- **Optical stochastic cooling** experiment
  - commissioning
  - demonstration
  - systematic studies
  - single-electron and advanced studies
- Octupole string studies in preparation for nonlinear integrable optics implementation based on **symplectic integrators**
- Effects of octupole channel on **instability thresholds**
- Interferometry of **single-electron undulator radiation**
- …

Conclusions

The IOTA/FAST facility is dedicated to **research** and **education** in **beam physics** and **accelerator technology**. An active and vibrant **research program** has started.

The **IOTA/FAST Scientific Committee** (ISC) **formulates priorities**, **reviews proposals**, and **oversees experiments**.

Experimental results will be presented at this meeting. We would also like to discuss **plans** for the near future and for the upcoming years.

Although progress was made, we need to **improve** on **proposal preparation** and **documentation of experiments**.

New ideas and **proposals are welcome** — they are the foundation of the scientific program.

Thank you for your attention

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